

SPECIFICATION**FE3312****M912****1 of 21**

Author

Daryl Oshatz

Department

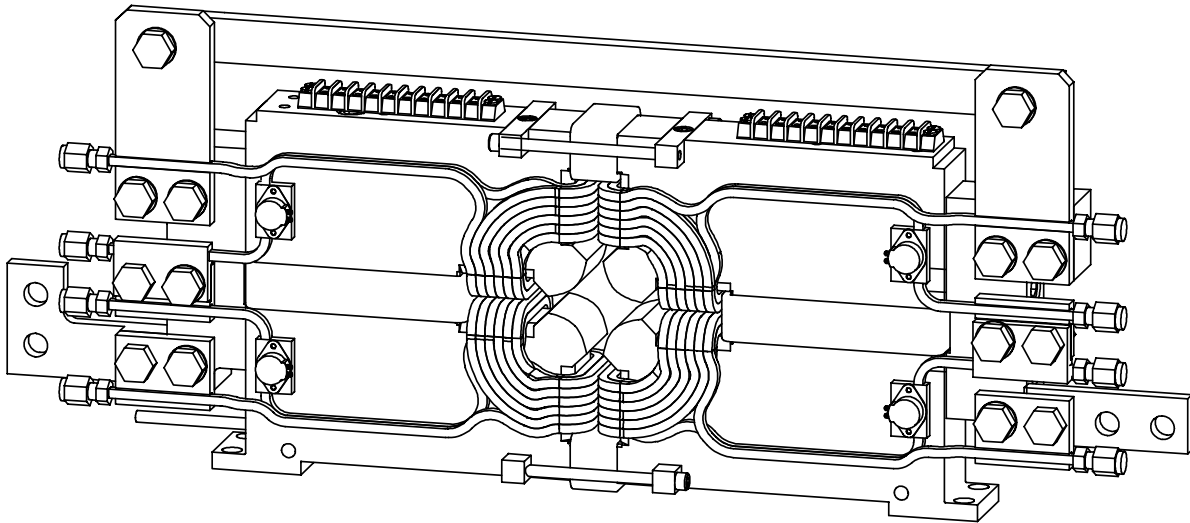
Mechanical Engineering

Date

12/16/99**RELEASE SUMMARY**

DATE	SUBMITTED BY	APPROVED BY	REV.	DESCRIPTION
12/17/99	Daryl Oshatz MEBT Lead Mechanical Engineer	Richard DiGennaro SNS - FE Chief Engineer	0	Initial Release

Title

**Quadrupole Magnet
Fabrication and Assembly**

Program - Project - Job

SNS-FE MEBT**Mechanical Transport Systems**

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1.0 GENERAL INFORMATION

1.1 Description

This Specification details the requirements for the fabrication, assembly, inspection, and test of the Front End (FE) Medium Energy Beam Transport (MEBT) Quadrupole magnets for the Spallation Neutron Source (SNS).

1.2 Scope

The Supplier shall complete the following work as specified herein and as shown on the Purchaser's drawings specified herein and/or in the Purchase Order:

1.2.1 Scope of Work

- Machine pole pieces.
- Wind main coils and steering coils.
- Assemble magnets.
- Perform tests and inspections.
- Document results of tests and inspections.
- Store and ship magnets.

1.2.2 Deliverable Items

In completion of the scope of work specified herein, the Supplier will deliver the following items:

1.2.2.1 Quadrupole magnet assemblies

Quantity shall be as specified in the Purchase Order.

1.2.2.2 Spare Coil Windings

Quantity shall be as specified in the Purchase Order.

1.2.2.3 Documentation

1.2.2.3.1 Main Coil Fabrication Procedure

See Section 3.2.2.1, Main Coil Winding Procedure, and Section 3.2.2.4, Impregnation Process Plan.

1.2.2.3.2 Steering Coil Fabrication Procedure

See Section 3.2.4.1, Steering Coil Winding Procedure, and Section 3.2.4.3, Impregnation Process Plan.

1.2.2.3.3 Manufacturing and Test Plan

See Section 4.2.3.1, Manufacturing Plan.

1.2.2.3.4 Quality System Description

See Section 4.1, Quality System Description.

1.2.2.3.5 Acceptance Test Documents

See Section 3.2.1.2, Pole Piece Assembly, the specific tests described Section 3.3.2, Acceptance Tests, and Section 4.2.3.2, Traveler.

1.2.2.3.6 Certificate of Conformance

See Section 4.2.6, Certificate of Conformance.

1.3 Abbreviations and Acronyms

AMS	Aerospace Material Specification
ANSI	American National Standard Institute
AWS	American Welding Society
MEBT	Medium Energy Beam Transport
psig	Pounds per square inch, gauge
QA	Quality Assurance
SNS	Spallation Neutron Source
VPI	Vacuum pressure injection

1.4 Definitions

Main Coil - electromagnetic coil that, when energized, creates one pole of a Quadrupole magnetic field.

Pole Piece - one quarter of the magnet core.

Steering Coil - electromagnetic coil that, when energized, creates a Dipole magnetic field.

2.0 APPLICABLE DOCUMENTS

The latest revision, edition, and addenda of the following documents in effect on the date of contract award are part of this Specification and, where referred to by title or basic designation only, are applicable to the extent indicated by the specific reference.

2.1 This Specification

2.2 Drawing Package

TITLE	BERKELEY LAB DRAWING NUMBER
Narrow Lower Flag	25B1204
Center Overlapping Flag	25B1224
Crossbar	25B1234
Fitting Modified	25B1244
Insulator Block	25B1254
Pole Piece - Top	25B1264
Pole Piece - Bottom	25B1274
Left Coil Winding	25B1284
Right Coil Winding	25B1294
Pole Piece Assembly - LH	25B1324
Pole Piece Assembly - RH	25B1334
Pole Piece Assembly - 32 MM Aperture	25B1346
Pole Piece Assembly - 42 MM Aperture	25B1366
Jumper Bar Flag	25B1404
Jumper Bar	25B1414
L-Shaped Bus Bar	25B1424
Straight Bus Bar	25B1434
Thermostat Mounting Plate	25B1444
Thermostat Assembly	25B1454
Vertical Steering Coil	25B1464
Horizontal Steering Coil	25B1474
Upper Left Coil Assembly	25B1484
Upper Right Coil Assembly	25B1494
Lower Left Coil Assembly	25B1504
Lower Right Coil Assembly	25B1514
Modified Terminal Block	25B1524
Power Cable Bracket	25B1554
Cable Bracket Strap	25B1564
32 MM Aperture Quadrupole with Steering	25B1576
32 MM Aperture Quadrupole w/o Steering	25B1586
42 MM Aperture Quadrupole with Steering	25B1596
42 MM Aperture Quadrupole w/o Steering	25B1606

2.3 Additional References

- *AMS - 2404C - Specification for Electroless Nickel Plating*
- *ANSI/AWS - A5.8-92 - Specification for Filler Metals for Brazing*

- *ANSI/AWS - C3.4-99 - Specification for Torch Brazing*
- *Berkeley Lab Specification M919, Copper Magnet Conductor*
- *Berkeley Lab Specification M920, Kapton Insulation for 0.187 Square by 0.125 ID Copper Conductor*
- *MIL-C-26074E, Electroless Nickel Requirements for Military Specification Coatings*

3.0 REQUIREMENTS

3.1 Responsibilities

3.1.1 Purchaser's Technical Representative

The Purchaser's Technical Representative shall be responsible for approving all processes and procedures used by the Supplier prior to their implementation. The Technical Representative shall also be made aware of any conflicts or questions arising during the performance of work in this Specification. The Purchaser's Technical Representative will be named in the Purchase Order.

3.1.2 Source of Documents

Procurement of all military, federal government, and industrial governing documents are the responsibility of the Supplier. Copies can be obtained from the appropriate professional organization referenced.

Copies of the Purchaser's documents required by the Supplier in conjunction with specified procurement functions will be included in the procurement package.

3.1.3 Perceived Conflicts Between Documents and Specification

In the event of a conflict between the documents referenced herein and the contents of this Specification, the contents of this Specification shall take precedence. All perceived conflicts shall be brought to the immediate attention of the Purchaser's Technical Representative and Subcontract Representative.

3.1.4 Equivalent Parts

Where drawings allow for use of equivalent parts, the Supplier shall be responsible for providing proof of equivalency. The Supplier shall not proceed with an equivalent part until written acceptance from the Purchaser's Technical Representative is received.

3.1.5 Test Procedures

The Supplier shall prepare travelers and procedures for inspections and tests performed in accordance with this Specification. The instructions shall include identification of the item to be inspected or tested, measuring and test equipment to be used if of special design, and details of inspection and test operations

to be performed. These travelers and procedures must be reviewed and accepted by the Purchaser's Technical Representative prior to use.

3.1.6 Changes Requested by the Supplier

The Purchaser encourages the Supplier to recommend alternate methods of fabrication and assembly techniques that might improve the quality of the finished product, expedite schedules, reduce costs, etc., to be implemented only with prior, written Purchaser approval and formal change authorization via appropriate channels in the Purchaser's Purchasing Department. If changes result in additional costs, these costs must be reviewed, approved, and executed as a change order to the purchase order.

3.2 Processes, Equipment, and Materials to be Furnished

Each Quadrupole magnet is an assembly of four Pole Piece quadrants. The machined, C1006 steel Pole Pieces are bolted and pinned together and the hyperbolic pole tips are precisely machined into the Pole Piece Assembly. The quadrants are disassembled for plating and reassembled with electrical windings. The electrical windings consist of four main coils electrically connected in series such that adjacent poles are of opposite magnetic polarity, forming a Quadrupole magnet. Some of the magnets also contain dipole steering windings. Pairs of steering windings are electrically connected in series such that the horizontal steering coils and vertical steering coils can be separately energized, forming Dipole magnets between pairs of poles. The completed assembly can be disassembled about its vertical centerline for installation around beamline components.

3.2.1 Pole Piece

Each Pole Piece shall be fabricated in accordance with Berkeley Lab Drawing numbers 25B1264 and 25B1274.

3.2.1.1 Annealing Process

All steel parts are to be machined and annealed according to the following process:

1. Rough machine parts with dimensions to be adjusted with extra material to accommodate final machined dimensions.
2. Anneal using a non-oxidizing neutral or inert atmosphere.
3. Heat to 1700 °F.
4. Hold at 1700 °F for 1 hour per inch thickness of material.
5. Furnace cool to 600 °F and then air cool.
6. Machine parts to finished dimensions.
7. Provide a certificate of conformance to the above procedure for each annealed part.

3.2.1.2 Pole Piece Assembly

Each steel Pole Piece Assembly shall be assembled and machined as shown on Berkeley Lab drawing numbers 25B1346 (32 mm bore) and 25B1366 (42mm bore). Prior to plating, the assembly shall be dimensionally inspected to verify conformance of the assembly with the dimensions stated on the drawings. The gap between opposite pole tips shall be recorded on each magnet's traveler.

3.2.1.3 Marking

Each steel Pole Piece and Pole Piece Assembly shall be marked as shown on Berkeley Lab drawing numbers 25B1346 (32 mm bore) or 25B1366 (42mm bore).

3.2.1.4 Plating

Each steel assembly, as shown in Berkeley Lab drawing numbers 25B1346 or 25B1366 (42mm bore), shall be disassembled and electroless nickel plated per AMS 2404C. A Class 1 (as plated, no subsequent heat treatment), Grade C (0.00015 inch minimum thickness) coating shall be applied as described in MIL-C-26074E, to all surfaces of parts. The coating shall have a maximum thickness of 0.0005 inches. Threaded holes and dowel holes shall not be plated.

3.2.2 Main Coil Fabrication

The main coils shall be fabricated as shown on Berkeley Lab drawings 25B1284 and 25B1294. The conductor shall be clean prior to application of insulating materials. Insulation materials and cleaned conductor surfaces shall be protected from skin oil, etc., by requiring shop personnel to wear clean, lint-free gloves while handling conductors and insulation.

3.2.2.1 Main Coil Winding Procedure

A coil fabrication procedure shall be written by the Supplier and must be accepted in writing by the Purchaser's Technical Representative prior to manufacturing. No deviation from accepted procedures shall be allowed without prior written approval from the Purchaser's Technical Representative.

No joints shall be allowed in the windings within an individual coil.

3.2.2.2 Inspect Conductor

The Supplier shall inspect the conductor upon receipt. The inspection shall verify cross-section dimensions; freedom from excessive warp, twist and camber; freedom from slivers, burrs, or other injurious defects on the surface; and freedom from bore obstructions such that the flow requirements are not compromised. The Supplier shall verify conformance of the insulated conductor to Berkeley Lab Specifications M919 and M920.

3.2.2.3 Ground Wrap Insulation

Per Berkeley Lab drawings 25B1284 and 25B1294, and prior to impregnation, wrap entire coil with half lap 0.50 wide by 0.007 thick fiberglass tape. Fill voids and spaces with glass roving or G-10 to minimize resin rich zones.

3.2.2.4 Impregnation Process Plan

The Supplier shall provide written descriptions of the processes and methods to be employed to impregnate and cure the windings. Prior to implementation, these procedures must be accepted in writing by the Purchaser's Technical Representative.

3.2.2.5 Impregnation and Curing Fixtures

Each coil shall be completely vacuum pressure impregnated (VPI) and cured to form a monolithic, essentially void-free structure. The Supplier shall design one or more sizing fixtures or VPI molds to accomplish this task.

The fixtures/molds must be sized so that cured coils shall be within all tolerances called out in Berkeley Lab drawings 25B1284 and 25B1294 and this specification. Consideration must be given to the thermal expansion of the tooling with respect to the windings during curing cycles. VPI molds must withstand 1 millitorr vacuum and 100 psig back-pressure during portions of the cure cycle.

3.2.2.6 VPI Impregnation and Curing Processes

The Supplier shall verify that the materials and procedures specified below were used to impregnate and cure the windings by referencing or including this process and material description in the Impregnation Process Plan (see Section 3.2.2.4).

3.2.2.6.1 Degas Coil/Mold

Prior to mixing and deaerating epoxy components, degas and evacuate the coil/mold assembly as follows:

- Evacuate the mold to as low an actual pressure as reasonably achievable (1 torr maximum). Maintain pressure until ready to impregnate.

3.2.2.6.2 VPI Formula

The following formula, or a Purchaser-accepted equivalent, is specified for vacuum impregnation of the coils. All materials shall be fresh; not from previously opened containers. It is recommended, but not required, that materials possessing at least 35% of their original shelf life shall be used. This formula consists of the items defined below in the quantities specified.

The Epoxy system to be used shall be:

Shell Epon Resin 815-C
Shell EPI-Cure (R) 3223 Curing Agent (Diethylenetriamine)
Armstrong Flexible Resin #1

The following components shall be used:

- Resin: 815, 100 parts by weight
- Hardener: DETA, 8 parts by weight
- Flexible Resin, 15 parts by weight

3.2.2.6.3 Mix and Deaerate Epoxy Components

Step 1

The chamber liner should have a volumetric capacity approximately two times that of the liquid. The chamber must have suitable viewing ports and access to the epoxy for stirring and temperature measurement. The vacuum pump and connecting lines should have sufficient capacity to pump the resin mixture down to a vacuum pressure of 200 millitorr in one hour or less. To allow free flow of the formulation into the coil potting mold or vessel, the vacuum chamber must be connected to the mold or vessel with a supply line or lines comprising suitable vacuum hose or tubing and valves. Great care must be exercised to prevent the occurrence of vacuum leaks or the presence of blocked sections or pockets holding air that the vacuum pump cannot remove. These air pockets could later be drawn into the mold.

The intake end of the supply line must enter the degas chamber at or near its highest point during pump-down so that air in the line between the chamber and the closed supply line valve will be pumped out. (One method of accomplishing this is to connect the line to a smooth rigid metal suction tube passing vertically down through a sliding vacuum seal in the top of the degas chamber. The lower end of this suction tube is raised above the liquid level during pump-down, and then slid deep into the liquid during the impregnation step.)

Step 2

Weigh the Resin, Hardener, and Flexible Resin directly into the degas chamber liner. Place liner with epoxy into the chamber. Stir slowly (~30 rpm) for 30 sec, then begin slow evacuation of the chamber while continuing to stir..

Step 3

Continue to pump down and stir for 5-10 minutes. The target pressure is 1 - 2 torr. Stir or agitate the mixture to completely deaerate. If the mixture foams excessively, reduce the pump-down rate. During pump-down, the following sequence of events should occur:

- Small bubbles form
- Foam rises (perhaps two times volume of original mix)
- Foam collapses
- Large bubbles form and break rapidly.

Continue to pump until “boiling” has dropped to a minor bubbling action, but do not exceed the target pressure and time. Note the final degas pressure.

3.2.2.6.4 Impregnation Procedure

When the mixing and deaeration of the epoxy formulation and the deaeration/drying of the coil and mold are complete, proceed with impregnation as follows:

- Bring the internal pressure of the mold to 4 to 5 torr by backfilling with dry nitrogen. Hold at this pressure throughout the impregnation process. At no time during the impregnation should the coil/mold assembly pressure drop below the epoxy’s final degas pressure.

- Lower the suction tube deep into the deaerated formulation (or otherwise submerge the supply line intake to the deepest point).
- Admit dry nitrogen into the tank of deaerated epoxy formulation until the liquid surface is at atmospheric pressure.
- Slowly open the supply line valve to the mold. Control flow rate into mold so that as the liquid rises it can penetrate all parts of the coil. Visually check for degassing in the supply line; there should be none. Some small amount of bubbles or foam may precede the epoxy column.
- When the impregnation is finished, be sure the reservoirs contain shrinkage compensation resin.

3.2.2.6.5 Cure Epoxy

The impregnated coils in their molds shall be carefully placed in a pressure controlled chamber.

- Back-pressure with dry nitrogen to 70 - 80 psig minimum, and maintain for entire cure time

3.2.2.6.6 Surface Evaluation

Supplier shall inspect the cured coil to verify freedom from defects. Removal of flash shall be permitted. The coil surfaces shall not be patched, machined, or otherwise processed without the prior written acceptance by the Purchaser's Technical Representative. There shall be no paint, coloration, or opacifier present in the cured compound.

The following criteria shall be used to evaluate the coil surfaces:

- "Dry insulation" spots are not acceptable.
- Surface cracks are not acceptable.
- Surface bubbles under 0.06" diameter are acceptable in a density of projected surface areas of less than 5%.
- Scratches of up to 0.01" deep, up to 0.02" wide, and up to 2" long are permitted.
- Nicks and pits less than 0.08" diameter and up to 0.001" deep are permitted.
- Nicks and pits less than 0.4" diameter and 0.016" deep are acceptable, provided any two such flaws are at least 0.5" apart, and the total area of such flaws within 0.25 in², including the large diameter nicks or pits, shall not exceed 0.16 in².

3.2.3 Main Coil Electrical and Water Connections

The electrical and water connections are shown in Berkeley Lab drawing numbers 25B1484, 25B1494, 25B1504, and 25B1514.

3.2.3.1 Braze Joints

All joints shall be silver-brazed according to ANSI/AWS A5.8-92 and C3.4-99. All brazing shall be done with very close control to prevent braze materials from flowing into the water passage. An alternate brazing process specification and procedure qualification may be substituted by the Supplier, once reviewed and accepted by the Purchaser.

Suggested Braze Filler Metal and Flux

It is recommended that joints between conductors and electrical terminations be brazed using BAg-7 alloy and Handy & Harmon "Handy Flux" or approved equivalent. Subject to approval of the Purchaser's Technical Representative, an alternate combination of braze products may be substituted by the Supplier.

3.2.3.2 Serial Number

Each main coil shall be serialized with a unique number furnished by the Supplier. This number shall be stamped on a foil that is then epoxied to the finished coil in a viewable location.

3.2.3.3 Acceptance Test

Each cured main coil shall undergo the tests prescribed in Section 3.3.2.1 and Appendix A prior to further assembly.

3.2.4 Steering Coil Fabrication

The steering coils shall be fabricated as shown on Berkeley Lab drawings 25B1464 and 25B1474. The conductor shall be clean prior to application of insulating materials. Insulation materials and cleaned conductor surfaces shall be protected from skin oil, etc., by requiring shop personnel to wear clean, lint-free gloves while handling conductors and insulation.

3.2.4.1 Steering Coil Winding Procedure

A coil fabrication procedure shall be written by the Supplier and must be accepted in writing by the Purchaser's Technical Representative prior to manufacturing. No deviation from accepted procedures shall be allowed without prior written approval from the Purchaser's Technical Representative.

No joints shall be allowed in the windings within an individual steering coil.

3.2.4.2 Inspect Steering Coil Conductor

The Supplier shall inspect the conductor upon receipt. The inspection shall verify cross-section dimensions and freedom from excessive twist.

3.2.4.3 Impregnation Process Plan

The Supplier shall provide written descriptions of the processes and methods to be employed to impregnate and cure the windings. Prior to implementation, these procedures must be accepted in writing by the Purchaser's Technical Representative.

3.2.4.4 Impregnation and Curing Fixtures

Each steering coil shall be completely impregnated with epoxy and cured to form a monolithic, essentially void-free structure. The Supplier shall design one or more sizing fixtures or VPI molds to accomplish this task.

The fixtures/molds must be sized so that cured coils shall be within all tolerances called out in Berkeley Lab drawings 25B1464 and 25B1474 and this specification.

3.2.3.5 Serial Number

Each steering coil shall be serialized with a unique number furnished by the Supplier. This number shall be stamped on a foil that is then epoxied to the finished coil in a viewable location.

3.2.3.6 Acceptance Test

Each cured steering coil shall undergo the tests prescribed in Section 3.3.2.1 and Appendix B prior to further assembly.

3.2.5 Pole Piece Assembly - 32 mm and 42 mm Apertures

The Pole Piece quadrants shall be assembled according to Berkeley Lab drawing numbers 25B1346 and 25B1366.

3.2.5.1 Inspect Coil Windows

Before a main coil or steering coil is mounted on a Pole Piece, the coil window shall be thoroughly checked and any burrs or chips removed.

3.2.5.2 Acceptance Test

Prior to further assembly, each main coil shall be tested as prescribed in Appendix A and Section 3.3.2.2, Ground Insulation. The results of this test shall be recorded on the main coil's traveler.

3.2.6 Assemble Top and Bottom Pole Pieces

As shown in the left half and right half Pole Piece assembly drawings, Berkeley Lab drawings 25B1324 and 25B1334.

3.2.7 Assemble Magnet

Left and right half Pole Piece Assemblies shall be assembled into a Quadrupole magnet as shown in Berkeley Lab drawings 25B1576, 25B1586, 25B1596, and 25B1606.

3.3 Technical Requirements

3.3.1 Performance Requirements

The main coil performance requirements are given in Appendix A. Steering coil performance requirements are given in Appendix B.

3.3.2 Acceptance Tests

All specified tests shall be performed on the coils and magnets at the Supplier's facility. Magnets or coils failing any test shall be subject to rejection or rework. If unsatisfactory results are obtained, the Supplier may decide to repeat any specified test. Verification of compliance with the requirements of this Specification shall be accomplished by test and/or analysis, inspection, and demonstration.

3.3.2.1 Coil Tests

After curing, the individual main coils shall be subjected to the tests specified in Appendix A and discussed in Sections 3.3.2.1.1 through 3.3.2.1.6. The individual steering coils shall be subjected to the test specified in Appendix B and discussed in Sections 3.3.2.1.1 through 3.3.2.1.4. The results of each test shall be recorded on the coil's traveler.

3.3.2.1.1 Impulse Test

There shall be no indication of breakdown between turns. Another similar test may be substituted, subject to prior written acceptance of the Purchaser's Technical Representative.

3.3.2.1.2 DC Resistance

Measure the DC resistance of each main coil and steering coil using a Kelvin bridge.

3.3.2.1.3 Inductance

Measure the inductance of each main coil and steering coil using an appropriate bridge-type instrument.

3.3.2.1.4 Ground Insulation

Entire main coil assemblies and steering coil shall be wrapped in aluminum foil to insure proper grounding of the insulation surface (the aluminum foil shall be removed at the completion of the test). An acceptable alternative is to carry out the test in the curing fixture.

3.3.2.1.5 Main Coil Leak Test

The Supplier shall notify the Purchaser's Technical Representative of any leaks. No repairs shall be made without the prior acceptance of the Purchaser's Technical Representative, and repair procedures are subject to his prior acceptance.

3.3.2.1.6 Main Coil Flow Test

See Appendix A.

3.3.2.2 Assembled Quadrupole Magnet Tests

The tests in Appendix C shall be applied to each completed Quadrupole magnet assembly at the Supplier's site. Sections 3.3.2.2.1 through 3.3.2.2.6 contain additional notes pertaining to these tests.

3.3.2.2.1 Assembly and Bore Geometry

Each completed Quadrupole magnet assembly, as shown on Berkeley Lab drawing numbers 25B1576, 25B1586, 25B1596, and 25B1606, shall be inspected to verify conformance with the drawings. The assemblies shall be dimensionally inspected to verify conformance with the dimensions stated on Berkeley Lab drawings 25B1346 and 25B1366. The gap between opposite pole tips shall be recorded on each magnet's traveler.

3.3.2.2.2 Ground Insulation

Perform test on main coils and steering coils. See Appendix C for details.

3.3.2.2.3 Water Leak Test

There shall be no leakage at any joint. The Supplier shall notify the Purchaser's Technical Representative of any leaks. No repairs shall be made without the prior acceptance of the Purchaser's Technical Representative, and repair procedures are subject to his prior acceptance.

4.0 QUALITY ASSURANCE

4.1 Quality System Description

The Supplier shall submit a written description of their Quality System, including all implementing procedures and instructions that will be involved in performing the work in this Specification, for review and acceptance prior to the commencement of work.

4.2 Quality Conditions

4.2.1 Evaluation of Supplier

The Purchaser will require a right of access to perform an evaluation of the Supplier's capability to complete the work in accordance with the requirements of this Specification prior to award of Contract. Such evaluation may include a review of historical data evidencing the Supplier's capability of providing a satisfactory product, a review of the Supplier's Quality Assurance program, manual, and procedures, and an evaluation of facilities and personnel.

The Purchaser may require that the Supplier establish in his sub-tier procurement documents those requirements necessary to ensure that each item delivered has been controlled, manufactured, and inspected to be in compliance with the requirements of this Specification. An unpriced copy of each sub-tier procurement order will be available for review by the Purchaser's Designated Representative.

4.2.2 Purchaser's Right to Witness Activities

The Purchaser reserves the right to have its Technical and or Quality Assurance Representative witness, at the place of manufacture, the inspections, analyses, and tests established under the Supplier's QA Program to demonstrate compliance with the Specification.

Representatives of the Purchaser shall have the right to visit the Supplier's facilities, or those of the subcontractors involved in this work, to witness any activities specified in this document.

4.2.3 Information to be Submitted

The Purchaser will require that all documents submitted by the Supplier are legible and of a quality and type that are capable of being reproduced (by dry process) and microfilmed.

4.2.3.1 Manufacturing Plan

The Supplier shall submit a Manufacturing Plan detailing the procedures to be used and the schedule to complete the work in this Specification. The Plan must be accepted by the Purchaser prior to the commencement of work.

4.2.3.2 Traveler

The Supplier shall create a traveler that contains all manufacturing, assembly, inspection, and test information for each magnet and its components. The traveler is to include the results of all tests prescribed in Section 3.3.2 and in Appendices A, B, and C. The traveler must be accepted by the Purchaser's Technical Representative prior to use.

4.2.4 Applicable Codes and Standards

When the Specification requires the use of special processes which must be performed by qualified personnel, procedures or equipment, measures taken to accomplish such qualification will comply with the requirements of applicable codes and standards.

4.2.5 First Article Tests

The Purchaser shall be notified of all first article tests at least five working days in advance. These tests may be witnessed by the Purchaser's Technical and or Quality Assurance Representative. Such tests will verify compliance with the requirements of the Specification. The Purchaser's acceptance of the first article test results will be obtained by the Supplier prior to shipment.

At this time the Supplier shall also demonstrate successful completion of all subassembly tests.

4.2.6 Certificate of Conformance

With each lot of items shipped against the Purchase Order, the Purchaser will require that the Supplier provide a Certificate of Conformance with the requirements of this Specification. The certificate will specifically identify the purchased material or equipment shipped and the procurement requirements (codes, standards, specifications, etc.) met by the purchased items. The certificate, in the form of an affidavit, will include a statement to the effect that all of the items shipped conform to all of the requirements of the Specification, and will be signed by a person whom the Supplier has made responsible for this Quality Assurance function.

4.2.7 Quality Assurance Records

The Purchaser will require that the Supplier have a system for the collection and maintenance of Quality Assurance records. QA records will be adequately protected from deterioration or damage, and will be made available to the Purchaser for inspection upon reasonable notice.

4.2.8 Transmission of Records

The Purchaser will require that copies of all manufacturing, inspection, and test records, e.g., travelers, receipt inspections, test procedures, etc., be transmitted to the Purchaser prior to the shipment of the magnets.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

The Supplier shall package each magnet assembly in a container suitable for ground transport. This shall include measures to prevent undue corrosion during shipment such as bagging and desiccant. Adequate support shall be provided to prevent damage of the assembly during shipment. The container shall be designed so that it may be reused, if desired. Each crate shall be stenciled on the outside with the contents including magnet assembly number, magnet serial number, container gross and tare weight, and container dimensions in inches.

5.2 Storage

Completed magnet assemblies shall be stored in a clean, dry area where they will be kept free from dirt, dust, soot, and other contaminants.

5.3 Shipping

The Supplier shall be responsible for the safe delivery of the magnet assemblies to Berkeley Lab. The assemblies will be inspected upon receipt and any damage incurred during shipping shall be the responsibility of the Supplier.

APPENDIX A

INDIVIDUAL MAIN COIL ACCEPTANCE TESTS

TEST DESCRIPTION	SPECIFICATION
Impulse test Sect. 3.3.2.1.1	Apply 50 V per turn impulse with rise time of 30 - 40 μ s, 10 pulses minimum.
DC resistance Sect. 3.3.2.1.2	0.0055 \pm 5% Ω at 72 °F. Record resistance and ambient temperature value for each coil.
Inductance Sect. 3.3.2.1.3	Record inductance and ambient temperature value for each coil.
Ground insulation Sect. 3.3.2.1.4	< 10 μ A at 2.5 kV DC for one minute. Record leakage current value.
Leak test Sect. 3.3.2.1.5	Hold at 250 psig water pressure for 5 min. Record leak status.
Flow test Sect. 3.3.2.1.6	Use water at 40 psig, 60 psig, and 80 psig inlet pressure, discharging into atmosphere. Minimum flow shall be 0.35 gpm at 40 psig. Record the flow at 40, 60 and 80 psig.

APPENDIX B

INDIVIDUAL STEERING COIL ACCEPTANCE TESTS

TEST DESCRIPTION	SPECIFICATION
Impulse test Sect. 3.3.2.1.1	Apply 400 V total impulse with a rise time of 80 μ s, 10 pulses minimum.
DC resistance Sect. 3.3.2.1.2	Horizontal Steering Coils: $0.753 \pm 5\%$ Ω at 72 °F. Vertical Steering Coils: $0.338 \pm 5\%$ Ω at 72 °F. Record resistance and ambient temperature value for each coil.
Inductance Sect. 3.3.2.1.3	Record inductance and ambient temperature value for each coil.
Ground insulation Sect. 3.3.2.1.4	< 10 μ A at 2.5 kV DC for one minute. Record leakage current value.

APPENDIX C

QUADRUPOLE MAGNET ASSEMBLY ACCEPTANCE TESTS

TEST DESCRIPTION	SPECIFICATION
Main Coil DC resistance Sect. 3.3.2.1.2	0.011 $\Omega \pm 5\%$ at 72 °F. Record resistance and ambient temperature value for each magnet.
Steering Coil DC resistance Sect. 3.3.2.1.2	Horizontal Steering Coils in series: 1.506 $\pm 5\% \Omega$ at 72 °F. Vertical Steering Coils in series: 0.676 $\pm 5\% \Omega$ at 72 °F. Record resistance and ambient temperature value for each coil.
Ground insulation Sect. 3.3.2.2.2	< 10 μA at 2.5 kV DC for one minute. Record leakage current value.
Leak test Sect. 3.3.2.1.5	Hold at 250 psig water pressure for 5 min. Record leak status.
Flow test Sect. 3.3.2.1.6	Use water at 40 psig, 60 psig, and 80 psig inlet pressure, discharging into atmosphere. Minimum flow shall be 0.35 gpm at 40 psig. Record the flow at 40, 60 and 80 psig.